PB82-223926

Five Resource Recovery Success Stories

Systech Corp.
Xenia, OH

Prepared for

Environmental Protection Agency
Washington, DC

1981

U.S. Department of Commerce
National Technical Information Service
NTIS

32272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	PB82-223926

4. Title and Subtitle: Five Resource Recovery Success Stories

5. Report Date: 1981

6.

7. Author(s): Gershman, Brickner & Bratton

8. Performing Organization Rept. No.

9. Performing Organization Name and Address:
Systech
245 North Valley Rd
Xenia, OH 45385

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) 68-01-6071
(G)

12. Sponsoring Organization Name and Address:
US EPA (WH-563)
401 M St. SW
Washington, DC. 20460

13. Type of Report & Period Covered: Tech. Info.

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

Case Studies of Five Successful Resource Recovery Operations

~~GRB performed~~ an analysis of five representative US resource recovery systems selected for their relative "success." The five systems are:

Chicago NW, Illinois
Ames, Iowa
Nashville, Tennessee
North Little Rock, Arkansas
Madison, Wisconsin

Each system was analyzed with regard to the driving forces leading to implementation; the project's organization, technology, economics; and, lastly, lessons learned from the experience. ~~The analysis will be published~~

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages: 62
	20. Security Class (This Page)	22. Price

FIVE RESOURCE RECOVERY SUCCESS STORIES

- Chicago NW, Illinois
- Ames, Iowa
- Nashville, Tennessee
- North Little Rock, Arkansas
- Madison, Wisconsin

This report (SW-) describes work performed
for the Office of Solid Waste under contract no. 68-01-6071
and is reproduced as received from the contractor.
The findings should be attributed to the contractor
and not to the Office of Solid Waste.

U.S. ENVIRONMENTAL PROTECTION AGENCY

1981

This report was prepared by Gershman, Brickner, and Bratton, Inc.(GBB) under subcontract to the Systems Technology Corporation (SYSTECH) through EPA Contract No. 68-01-6071. The GBB Project Manager for this effort was Thomas Barnett who was assisted by Robert Brickner, Charles Peterson, Gary Liss, and William T. Rusin of GBB's staff. The authors also wish to acknowledge the assistance provided by the SYSTECH Project Officer, Gerald Degler, and the EPA Project Officer, Randolph Chrismon.

FIVE RESOURCE RECOVERY SUCCESS STORIES

In the ten years since the primitive EPA-sponsored St. Louis RDF project first demonstrated its general feasibility, resource recovery in this country has experienced a great deal of activity and undergone many transformations. As with any developing industry, there have been successes and failures. Public interest and awareness concerning resource recovery has experienced similar vicissitudes. Much of the negative public response has been the result of several widely publicized failures within the industry. This negativism has become so pervasive by now that the most often encountered public reaction to resource recovery seems to be that it simply doesn't work in this country.

This perception is not only unfair, it is untrue. It is unfair because it is too often overlooked that the waste-to-energy industry in this country is still relatively young. Many technologies are still developing; many systems are only in their second or third generation. Operating problems are expected in an industry at this stage. They are by no means indicators of a failed concept or technology.

The "it doesn't work" perception is also untrue. As you read this there are communities in this country whose solid waste is disposed of every day, reliably, and economically by resource recovery facilities. In most cases, these systems are not making anyone rich, nor are they performing flawlessly, but they are getting the job done. In an effort to increase the public's awareness of this fact, this report examines five such systems:

- Chicago (NW), Illinois
- Ames, Iowa
- Nashville, Tennessee
- North Little Rock, Arkansas
- Madison, Wisconsin

These facilities were selected for a variety of reasons. No one conventional measure of success will apply: not all can be considered economic successes; most have experienced serious technological problems; many began operation only after long, difficult, and almost perverse implementation processes. Nonetheless, each of these facilities has been in operation long enough to determine if they "work". They do.

The descriptions that follow do not attempt to provide technical or financial blueprints. The individual case studies focus on why and how these particular

communities implemented their systems and, finally, on how other communities that may be considering similar undertakings can profit from their experience.

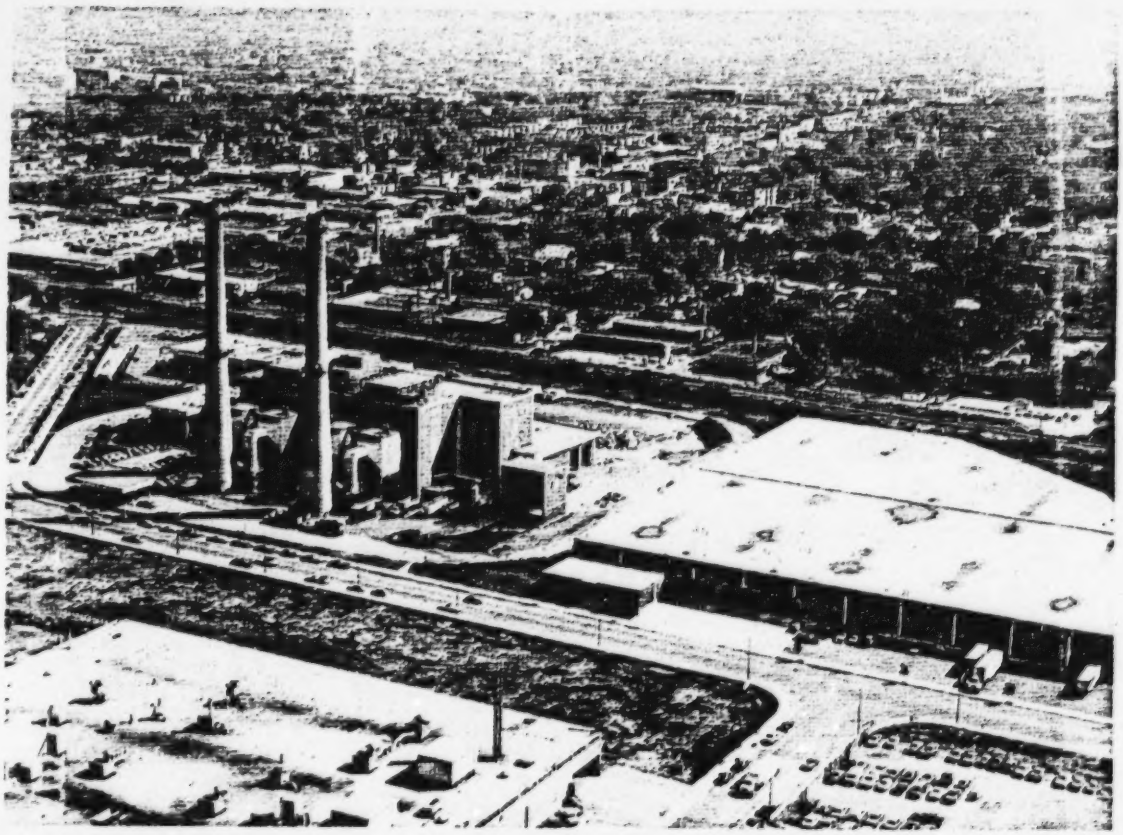
FIVE RESOURCE RECOVERY SUCCESS STORIES

TABLE OF CONTENTS

		Page
INTRODUCTION		i
CHAPTERS:		
CHAPTER 1:	Chicago NW, Illinois	1-1
CHAPTER 2:	Ames, Iowa	2-1
CHAPTER 3:	Nashville, Tennessee	3-1
CHAPTER 4:	North Little Rock, Arkansas	4-1
CHAPTER 5:	Madison, Wisconsin	5-1
EXHIBITS:		
EXHIBIT 1A:	Chicago, NW Chronology	1-4
EXHIBIT 1B:	Cut-Away of Chicago, NW Facility	1-5
EXHIBIT 2A:	Ames Chronology	2-4
EXHIBIT 2B:	Ames Process System Diagram	2-5
EXHIBIT 2C:	Ames Capital Cost Breakdown	2-8
EXHIBIT 2D:	Ames Financial Summary	2-9
EXHIBIT 3A:	Nashville Chronology	3-5
EXHIBIT 3B:	Cross-Section: Nashville Thermal's Central Facility	3-7
EXHIBIT 3C:	Capital Cost Elements of Nashville Thermal	3-9
EXHIBIT 3D:	Nashville Thermal Financial Review	3-10
EXHIBIT 4A:	North Little Rock Chronology	4-6
EXHIBIT 4B:	N. Little Rock Capital Cost Breakdown	4-9
EXHIBIT 4C:	N. Little Rock Financial Summary	4-10
EXHIBIT 5A:	Madison Chronology	5-3
EXHIBIT 5B:	Flow/Diagram Materials Balance	5-6
EXHIBIT 5C:	Capital Costs	5-8
EXHIBIT 5D:	Madison Financial Summary	5-10

CHAPTER 1

CHICAGO, ILLINOIS



Introduction

The Chicago Northwest Waste-to-Energy Facility is the largest capacity, continuously operating waste-to-energy facility in the Western Hemisphere. Since opening its doors in October 1970, the plant has burned more than three million tons of solid waste and generated more than 16 billion pounds of steam.

The Northwest Facility is designed as a mass burning combustion process to handle up to 1600 tons each day of residential and commercial solid waste collected publicly by the City of Chicago. Steam is sold to a candy manufacturer located nearby for processing operations, delivered to an adjacent city vehicle maintenance yard for space heating and vehicle cleaning, and used extensively in the plant for driving large loads and for heating and air conditioning. The facility is owned and operated by the City of Chicago.

Driving Forces

The Chicago Northwest Facility was the result of a long history of commitment by the City to innovations in solid waste management. As a result of previous experiences, the City leaders did not have to be sold on the benefits of the resource recovery approach to solid waste management. Chicago provides a good example of the social, political, technical and economic climate that enhances the development of a waste-to-energy program.

The key initial concerns of City leaders were that solid waste disposal costs be minimized, the wastes reduced in volume, and the emission from the facility meet federal air pollution standards. It was the latter goal which was of greatest importance in the City's decision to proceed with the most modern technology available from Europe. The passage of the Clean Air Act in 1965 directly affected their 1966 study selecting a technology for a new waste disposal facility. Anticipating more stringent pollution standards in the future, the City felt that a water-walled boiler system with electrostatic precipitators would enable them to meet whatever standards were enacted. The other three incinerators operating in Chicago at the time, had some type of wet scrubber for air pollution control which proved unable to meet the increasingly stringent state and federal air pollution standards.

Project Organization

The Chicago Northwest Facility was developed in a traditional manner by the Department of Public Works of the City of Chicago. The City floated general obligation bonds to finance the facility's construction, and obtained the services of the engineering firm of Metcalf and Eddy to design the facility. Construction was jointly supervised by engineers from the City and Metcalf and Eddy, but completed by local contractors. The design of the combustion system was based on the Martin system from Europe, offered under the American licensee of IBM-Martin (now UOP). The City acted as general contractor and awarded a number of separate contracts for equipment and construction. Separate contracts were used for such items as refuse burning systems, substructures, general construction and site work, cranes, a bulk refuse shredder, two 250 foot chimneys and an access road to the 11 acre landscaped site.

As the City collected all their own residential and commercial solid waste, there was no need for any waste stream contracts with neighboring municipalities as in many resource recovery projects. Due to the nature of the financing, there was also no need

for specific waste stream control ordinances to assure that project financing would be supported by tipping fees. In fact, the City pays no direct tipping fee; the resource recovery facility is simply a line item in the budget for the Department of Public Works.

Until recently, steam generated by the facility was used internally and any remaining amount was condensed on the roof. As the price of energy continued to increase in the Northwest Industrial Park, interest developed in purchasing the steam. A contract with Brachs Candy was negotiated for the purchase of the steam at $2.25/1000 pounds. Although the City recognized that this was a low price for the steam, they believed it was better than just condensing the steam into the atmosphere, and that it might retain Brachs as a major manufacturing plant in the City which was critical for the City's economic development goals.

A chronology of major milestones leading to implementation of the Chicago NW facility is presented in Exhibit 1A.

Technology Description

The Chicago Northwest Facility utilizes the mass burning technology engineered by the Martin Company of West Germany. The system involves controlled combustion of unprocessed solid waste on reverse-reciprocating grate stokers. The stokers provide sufficient agitation of the fuel bed to enable maximum burn-out. Controlled preheated combustion air is introduced through small openings in the grate and overfire air is directed through nozzles in the front and rear furnace walls to create turbulence in the combustion gases. Burning refuse is pushed back underneath freshly fed refuse to achieve continuous drying, volatilization, ignition and burnout of the waste. A uniform burnout of 98% of all combustible material is achieved, and the solid waste is reduced 92% by volume and 82% by weight.

The Northwest Facility has four Martin combustion systems operating in parallel, with any three of the boilers capable of handling the average daily delivered waste quantity of 1000 tons per day. The four boilers are connected to four electrostatic precipitators, which reduce the particulate emissions by 97%, to 0.05 gr/scf. A cut-away drawing of the facility is shown at Exhibit 1B.

The waste is burned at 1800°F and steam is produced at 275 psi and 414°F at a rate of up to 440,000 pounds/hour. There is a 10,000 cubic yard waste storage pit which enables waste to be dumped continuously when collected, and metered into the furnaces on a controlled basis to meet the steam loads. The tipping floor is under negative pressure so that all odors and dust are drawn into the furnaces from the

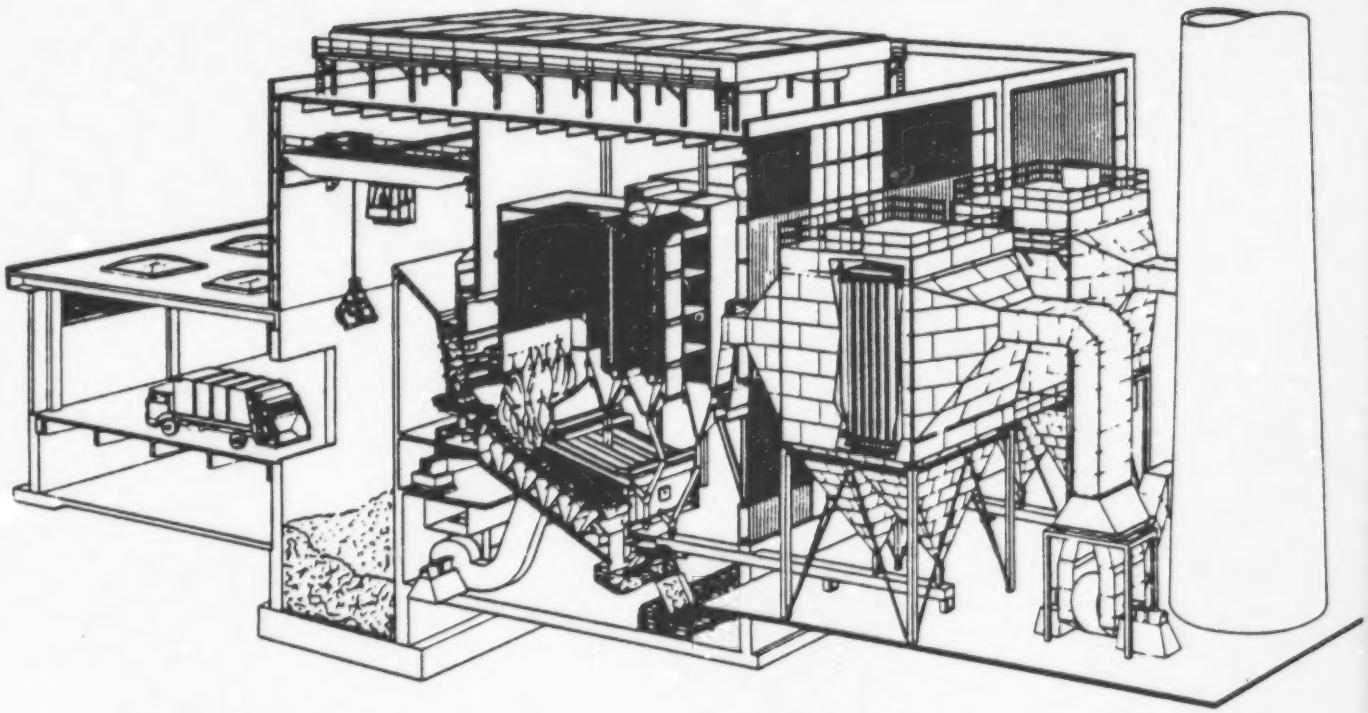
EXHIBIT 1A

CHICAGO, N.W. CHRONOLOGY

Date	Event
1966	City Study to assess technology for waste disposal
1967	Design started by Metcalf and Eddy
1967	General Obligation Bonds floated
1968	Design completed
1968	Construction started
1970	Construction completed
1971	Dedication of Northwest Incinerator
1979	Brachs Candy Contract signed
1980	Construction of Steam Line begun
1980	Steam Line completed
1980	Dedication of Northwest Waste-to-Energy Facility

EXHIBIT 1B

CUT-AWAY OF CHICAGO, N.W. FACILITY



suction of the forced draft underfire air fans. As a result, odors and dust are prevented from escaping to the outside environment, allowing the facility to be a good neighbor to the adjacent industries in the Northwest Industrial Park.

Economics

As noted above, the City of Chicago floated general obligation bonds to finance this project. The total capital cost of the project was $23 million. Of these funds approximately $2-3 million was used to build the adjacent municipal garage, which maintains all of the City's solid waste collection fleet. Excluding the costs of the garage, this project cost $12,500 per ton of design capacity. Using Marshall & Swift escalation factors, the facility's total cost in 1980 dollars is estimated to be $24.499 per design ton.

As is the case with public works operations in many cities, the annual costs for the Chicago NW facility are not kept separately, but are buried within the Department's general budget. This practice reflects the City's attitude that effective, reliable solid waste disposal is more important than high revenues or bottom-line economics.

The City estimates the 1980 operating and maintenance costs to be $5,184,000 or approximately $18 per input ton.

Lessons Learned

The Chicago Northwest Facility provides a demonstration of successful waste-to-energy technologies. Its ten years of operating experience provide one of the longest track records in the resource recovery field in the United States. Some of the lessons learned from the Chicago experience follow.

Chicago Northwest successfully demonstrated the ability of electrostatic precipitators to meet the stringent new state and federal air pollution control codes. In contrast to many of the U.S. incinerators built in the 1960s which were being closed, the Chicago Northwest plant's pollution control capabilities were used by the U.S. Environmental Protection Agency to develop its air emission standards.

Probably the most difficult times in the early history of the Chicago Northwest facility were related to the lack of customers, which necessitated the condensing of excess steam. During the first nine years of operation, any steam produced beyond that which was needed for internal operations was simply condensed into the atmosphere.

Besides being a waste of valuable energy, this resulted in a series of technological weaknesses in the early years of the project. The tubes froze up during the bitter Chicago winters and subcoolers froze, buckled, and otherwise failed near their connections to the facility.

Between 1970-1979, 16.3 billion pounds of steam were produced, and only 7 billion pounds were used for internal operations of the facility and the City's garage. Although this saved 75 million gallons of heating oil for the garage, the waste of steam became of increasing concern as the price of energy escalated. It is now generally recognized that energy revenues can contribute between 50-70% of the costs of operating a resource recovery facility, and therefore projects should not be implemented without a secure energy market. However, at the time when this facility was constructed, the City's main goal was solely proper solid waste disposal at the least cost.

Today, they are actively pursuing revenues from the sale of steam to Brachs Candy, but their main objective remains the disposal of solid waste. Landfill capacity constraints and environmental concerns, rather than the desire to provide a cheap energy alternative led to resource recovery as the means of achieving that objective.

CHICAGO NW REFERENCES

City of Chicago, Department of Public Works, and Department of Streets and Sanitation. Undated. "Northwest Waste to Energy Facility".

Ellis, John, Operator, Chicago Northwest Incinerator. Personal communication. March 24, 1981.

Nigro, Emil, Coordinating engineer, Chicago Northwest Incinerator. Personal communication. March 24, 1981.

Nigro, Emil, and Jon Peacy. "Resource Recovery in the City of Chicago: An Historical Perspective". In: Proceedings of the National Waste Processing Conference, Washington, D.C., May 11-14, 1980.

Pikarsky, Milton. Chicago's Northwest Incinerator. Civil Engineering ASCE, September, 1971.

Ryder, William, Chicago Department of Public Works. Personal communication. March 30, 1981.

Stabenow, Georg. "Performance of the New Chicago Northwest Incinerator". In: Proceedings of the National Waste Processing Conference, New York, New York, June 4-7, 1972.

CHAPTER 2

AMES, IOWA

Introduction

One of the communities most directly influenced by the relative success of EPA's St. Louis RDF demonstration project was the City of Ames, Iowa. The 1971 EPA project came at a time when Ames was especially impressionable since it was actively seeking an alternative to landfill disposal. The system ultimately implemented in Ames relected this influence in that it incorporates the same basic design elements that were demonstrated in the St. Louis project: the processing of solid waste into RDF for combustion with coal in electrical utility boilers. Despite the system's failure to live up to original performance expectations, it has been successfully disposing of waste from Ames and 12 surrounding communities for over 5 years now. As such, it represents one of the more successful examples of the RDF approach to resource recovery.

Driving Forces

Rising landfill and fuel costs provided the basic impetus for resource recovery in Ames. In 1971, disposal costs at the City's publicly operated landfill began to approach $2.00 per cubic yard (around $8 per ton). These high costs, coupled with rapidly diminishing capacity in the existing landfill, caused the City to look for alternative disposal methods. Although there is abundant open land area around Ames, the majority is prime farmland and the local citizenry has a strong ingrained resistance to using acreage with any agricultural potential as a waste material burial ground.

An additional factor was that compliance with sulfur dioxide air quality standards was forcing the City's publicly owned electric utility to use low sulfur Wyoming coal instead of less expensive locally mined Iowa coal. When the EPA sponsored St. Louis project's test results indicated that cofiring coal with RDF reduced sulfur emission, it added to the impetus for a resource recovery system.

Finally, the collection of tendencies favoring resource recovery were coalesced by State legislation requiring communities to develop environmentally acceptable solid waste management plans by July, 1975. As the largest solid waste generator in the region, Ames took the lead in developing a program for compliance.

Project Organization

Although the system provides waste disposal service for 13 communities, the City of Ames is the sole owner and operator. The decision that the City alone would take responsibility for the system was based primarily on two considerations: the City generates over 50% of the waste within the service area; and the City owns the system's energy market, the Ames municipal electric power plant.

The determination to implement a waste disposal system based on the processing of waste into RDF for sale to the Ames power plant was the result of a feasibility study conducted in 1971. The feasibility study was commissioned by a committee formed in 1971 to study alternatives to landfilling.

The feasibility study indicated that the optimum system would be based on more waste than Ames could generate alone. To address this problem, the City developed contracts with 12 surrounding communities and three local institutions. In the contracts, the communities and institutions agreed to deliver all of their wastes to the facility for 25 years (until June 30, 1999). Furthermore, according to the contract, the costs of the system are shared equally among the participants on a per capita basis.

The system is administered by the Ames City Council and the Ames City Manager. However, the specific rules and procedures for the use and workings of the system are reviewed annually by a rules committee composed of the mayor or chairman of the Board of Supervisors for each entity participating in the system. This input mechanism made the waste control contracts more politically acceptable.

In addition to securing waste supply, the other longer term contractual arrangements typical of resource recovery systems were for the purchase of the energy or materials products. In this case, arriving at a mutually acceptable arrangement was greatly facilitated by the fuel that the market was a municipally owned utility. The utility cofires the RDF with either coal or gas and credit is given to the resource recovery facility for fossil fuel costs offset on a straight Btu-equivalent basis.

Sales or recovered metal products are based on current market demand and prices. The major ferrous purchaser is Vulcan Materials Company in Gary, Indiana.

Once the City determined to accept the recommendations of the feasibility study, it proceeded to follow a typical A & E procurement. The consulting engineering firm that had performed the feasibility study was awarded the design contract and in 1974 construction bids were awarded. This chronology of significant events is presented in Exhibit 2A.

Technology

The Ames Solid Waste Recovery System consists of two facilities (Exhibit 2B): a processing plant; and the municipal electrical utility, located 900 feet away. Major subsystems in the processing plant (presented in the order of waste flow through the system) are the following: primary shredder, electromagnet (for ferrous metal recovery), secondary shredder, air density classifier, and pneumatic conveying system. Miscellaneous subsystems include a paper baler, oil storage tank, and wood chipper. An Atlas storage bin is located adjacent to the utility.

Haulers deposit their waste on the tipping floor. The tipping floor can store approximately 350 tons of raw refuse. A front-end loader pushes refuse to a conveyor for transport into the process line.

The Ames system consists of a single process line based on two stage shredding. The process line was designed for 50 tons per hour (TPH) but is currently averaging 25-35 TPH. The shredders are American Pulverizer Company horizontal-rotor hammer mills.

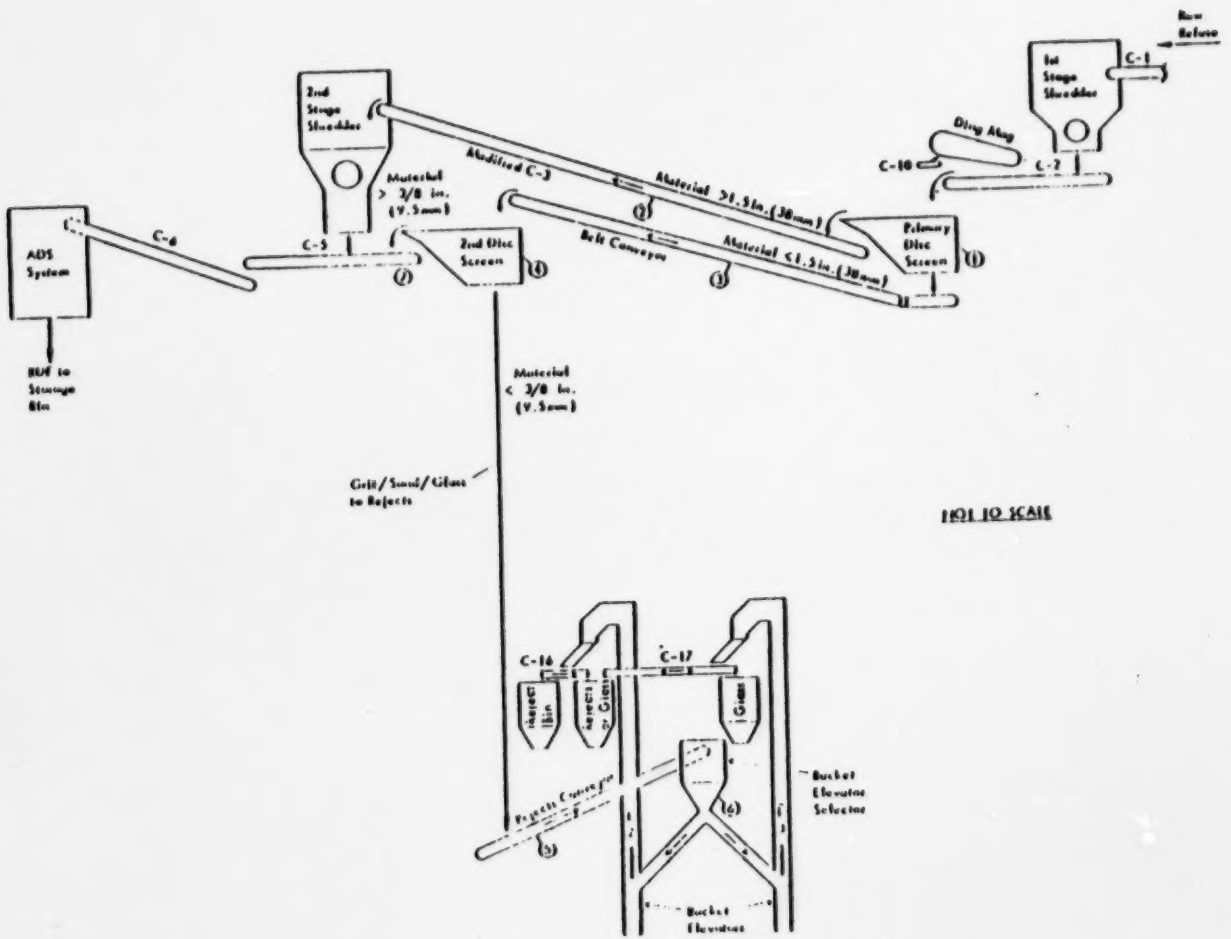
EXHIBIT 2A

AMES CHRONOLOGY

Date	Event
1971	Solid waste problem identified
1972	Task force appointed by the Mayor of Ames to investigate landfill alternatives
1972	Task force recommendation supporting resource recovery system accepted
1972	Engineering consulting firm of Gibbs, Hill, Durham, and Richardson (GHDR) of Omaha, Nebraska hired to prepare feasibility study
1973	GHDR contracted to design a 50 ton per hour refuse derived fuel facility
1974	Construction bids awarded. Prime contractor was J.D. Thompson and Sons of Ames
1975	Plant start-up commenced
1975	Commercial operation commenced
1976	Plant processing waste at full capacity

EXHIBIT 2 B

AMES PROCESS SYSTEM DIAGRAM



About 7% of the total waste processed is recovered as ferrous metal. One-quarter of the 7% is unprocessed "white goods" (refrigerators, stoves) separated from the raw waste on the tipping floor. The remaining three-quarters is recovered in the process line's ferrous recovery system. A three-stage, belted electromagnet between the primary and secondary shredders, and two natural magnets in the conveying system comprise the ferrous recovery system.

Rader Pneumatics manufactured the vertical-chute air density classifier. The light fraction contributes to the RDF. The heavy portion is transported to a trommel screen. Grit, glass, and other noncombustible fall through the trommel.

Installment of a disc screen grit removal system in the process line in 1978 improved RDF fuel and pneumatic transport characteristics. Prior to installation of the disc screens, RDF production averaged around 80-85% (by weight) of raw refuse received. Currently, 67% (by weight) of the raw refuse received is converted to RDF.

After the raw waste has been prepared for combustion at the processing plant, it is pneumatically piped 500 feet to the storage bin adjacent to the utility. The storage bin holds 550 tons of RDF. It unloads via variable speed, motor-driven bucket sweeps and a drag conveyor system.

The Ames Municipal Electric Power Plant is the second major facility in the resource recovery system. Three boilers at the Ames Municipal Electric Power Plant can accommodate RDF. They have a combined capacity of 55 MW. Two boilers (#5 and #6) fire RDF only. These boilers have spreader strokers and traveling grates. Boiler #5 produces 95,000 lbs. steam per hour (7.5 MW electricity) at maximum capacity. Riley manufactured this boiler, installed in 1951. The fly ash collection equipment vendor was Western Multiple Cyclone. Boiler #6, designed to generate 125,000 lbs. steam per hour (12 MW electricity) was manufactured by Union Iron Works. This unit was installed in 1958. American Blower Multiple Cyclone designed the dust collection equipment. Boiler #7, the third RDF-fired boiler, fires an RDF/coal mixture (typically 20% : 80% suspension). Installed in 1968, the boiler was supplied by Combustion Engineering Company. At capacity, this boiler generates 360,000 lbs. steam per hour (35 MW electricity). Air emissions are controlled by electrostatic precipitators built by American Standard. Fly ash, bottom ash, and boiler slag are disposed of in the municipally owned and operated landfill.

Economics

Financing of the $6,130,000.00 capital construction cost (1974 dollars) was achieved through two mechanisms. The first mechanism covered $5,300,000.00. Financing involved 20-year general obligation bond issues sold at 5.3% interest (1974 dollars). This interest rate was granted the City of Ames by a special act of the Iowa State Legislature. The low rate increased the bond value to potential buyers. A second financing arrangement involved $265,000.00 in revenue sharing funds for the purchase of the facility site and feasibility study. The remaining $565,000.00 was financed using miscellaneous City revenues. This capital cost breakdown is shown in Exhibit 2C. The costs of the 1978 major modifications are also shown in Exhibit 2D, followed by the estimated 1980 cost of the full system based on Marshall & Swift cost indices.

Lessons Learned

Ames also provides lessons in project procurement and implementation. Planning and implementation was facilitated when the City opted to take the lead in a regional system where it controlled the majority of the waste as well as the energy market. The City was able to secure additional waste through long term contracts; however, the system was designed for a larger capacity than has been obtained to date. This under-utilization has seriously affected the system's overall economics. The experience points to the importance of matching system design capacity to the quantity of waste that has actually been secured.

Despite these problems, the system at Ames has provided continuous waste disposal for 13 communities for over five years now. With many of the operational problems resolved and energy revenues rising, the future looks promising for this first and operatonal RDF system.

EXHIBIT 2C

AMES CAPITAL COST BREAKDOWN

Direct Construction Costs:		
Equipment (1973 dollars)	$2,098,622	
Building and Installation (1974 dollars)	$3,240,135	
Engineering (1974 dollars)	$ 376,836	
Land Acquisition (1974 dollars)	$ 107,841	
		$5,823,434
Indirect Costs (1975 dollars)		
Plan Start-Up	$ 236,430	
Interim Financing (Mostly Interst)	$ 249,975	
		$ 486,405
Total Original Capital Investment		$6,309,839
Costs of Major Modifications (1978 dollars)		
Dump Grate Boiler #7	$ 113,380	
Disc Screen System	$ 232,003	
Dust Collection System	$ 165,592	
		$ 510,975
Total Adjusted Capital Investment		$6,820,814
Total System Capital Costs in 1980 dollars		$11,140,320

EXHIBIT 2D
AMES FINANCIAL SUMMARY
January 31, 1981

Revenues:	Total Annual	Input $/Ton*
Refuse Sale for Fuel	$380,002.88	$9.48
Sale of Metals	77,094.39	1.92
Public Fees	19,299.90	.48
Regular Customer	27,640.67	.69
Woodchips	1,598.67	.04
Paper Recycling	910.80	.02
Sanitary Landfill	40,513.10	1.01
Reimbursements & Refunds	2,376.08	.06
Other Governmental Units	12,185.16	.30
L.S.U. Participation	116,643.47	2.92
	$678,265.10	$16.92
Expenditures:		
Operations	$1,002,570.41	$25.02
Bond Interest	229,350.00	5.72
Bond Principal	300,000.00	7.49
Equipment Reserve	12,500.00	.31
	$1,544,420.41	$38.54
Cost to be shared	$ (866,155.31)	($25.63)**
Adjustments:		
Less:		
DOE Oil Credit	$ 171,833.71	$4.29
EPA Contributions	40,000.00	1.00
Damage Claims	1,958.00	.05
	$ 213,791	$5.34
Net Cost of System	$ 652,369	$16.28
		($19.30)**

* Based on total input tonnage of 40,076 per year.

** Refers to cost per ton to participating communities only. Based on 33,793 tons per year which does not include waste from governmental units or L.S.U.

Reproduced from best available copy.

AMES REFERENCES

Chantland, Arnold O. The Ames Refuse Derived Fuel Production Facilities. Department of Public Works, Ames, Iowa.

City of Ames. Contract and Agreement for the Use and Support of a Solid Waste Reclamation, Recycling and Disposal System.

City of Ames. 1978. Energy from a Wasted Resource: The Ames Experience. HUD Grant Number H-2654.

City of Ames. Solid Waste 1980. A report of operating economics.

Godfrey, Kneeland A., Jr. 1976. Recycling refuse into energy. Civil Engineering ASCE, pages 85-93.

Holloway, Robert. 1978. Comparing the Ames and St. Louis resource recovery projects. Waste Age, pp. 33-40.

Olexsey, Robert A. 1980. Environmental perspectives on the Ames, Iowa resource recovery plant, presented at the 73rd Annual Meeting of the Air Pollution Control Association, June 22-27, 1980. Montreal, Quebec.

Sedore, Keith J. Use of Community Refuse for Boiler Fuel. Ames Municipal Electric System, Ames, Iowa.

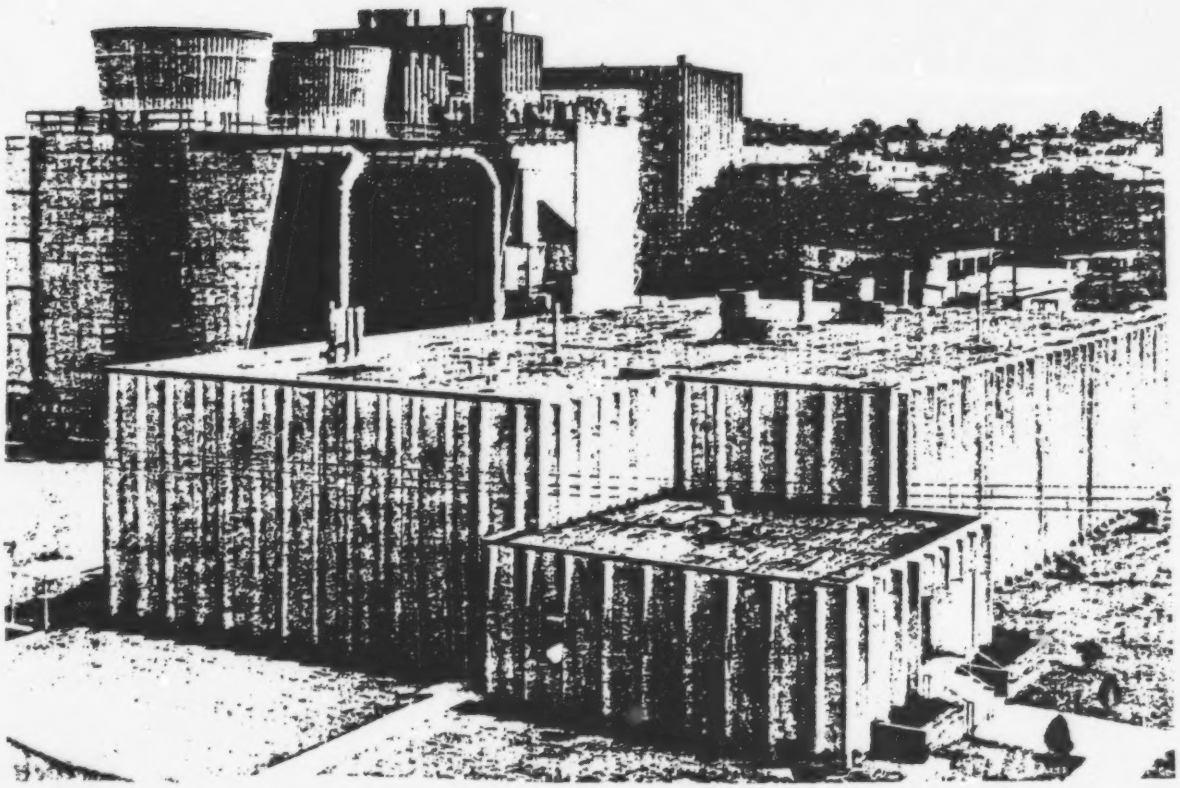
Sprenkel, Terry V., and Arnold O. Chartand. 1977. Ames celebrates birthday by analyzing operational and administrative experiences. Solid Wastes Management, January 1997, page 14-18.

U.S. Environmental Protection Agency. Evaluaton of the Ames Solid Waste Recovery System. Part I - Summary of Environmental Emissions: Equipment, Facilities, and Economic Evaluation. EPA - 600/2-77-205, November, 1977.

U.S. Environmental Protection Agency. Evaluation of the Ames Solid Waste Recovery System. Part II - Performance of the Stoker Fired Steam Generators. Prepared under EPA Grant No. R803903-01-0.

CHAPTER 3

NASHVILLE, TENNESSEE



Introduction

In 1972 there were over forty district heating plants operating in the United States and three in Canada using conventional fossil fuels. These operations represent a significant potential market for resource recovery. The first U.S. system to take advantage of district heating's potential was the Nashville Thermal Transfer Corporation (Thermal). Thermal was established in 1970 to meet the steam and chilled water demands of downtown Nashville's district heating/cooling system as well as to meet a portion of the City's long term solid waste disposal needs.

The system began operation in 1975 with two 360 ton per day (TPD) mass burning water wall incinerators. The facility's startup received a great deal of attention and it was widely viewed as the wave of the future. However, serious problems began to develop immediately, mostly related to the system's inability to meet air quality standards. The resulting bad publicity gave Thermal and resource recovery in general a very negative public image which is only now beginning to be dispelled. As will be shown in the following discussions, the negative image is largely undeserved. Nashville

made modifications in 1976 which corrected its emission problems and it is currently processing 140,000 tons of solid waste annually while providing energy to 28 buildings in downtown Nashville.

Driving Forces

The project began in mid-1969 when Nashville Mayor Beverly Briley commissioned a feasibility study for constructing a central energy facility to provide heating and cooling to municipal buildings. Nashville had experienced a significant increase in commercial, institutional, and government office building complexes and this downtown expansion was expected to increase into the 1970s. The growth brought with it the demand for economical and convenient energy for use in the downtown community. Both City and State office building complexes were already confronting the need to replace their individual boilers when the Mayor's more expansive urban renewal project was first conceived. It naturally followed for them to join forces in the central heating and cooling system concept. When the consulting engineers' study established conclusively that the concept was economically and technically feasible, the project was expanded to include servicing the entire downtown area. This new plan became the Thermal Project.

Coincident with the planning of the Thermal Project, a separate urban renewal project in downtown Nashville planned to redesign and rebuild sewers, water lines, and electricity distribution systems, there by necessitating the rebuilding of downtown streets. The interface of both these projects was a major factor in overcoming the usual economic development impacts associated with major downtown construction projects.

Nashville's urban growth meant not only new demands for energy, but also an increased accumulation of solid waste. Because of the scarcity of open space and unique geologic conditions in the area, not one of the solid waste disposal sites in use by Nashville in 1972 met State of Tennessee regulations. Solid waste disposal became a critical problem. One of the more promising solutions appeared to be resource recovery. As momentum for a resource recovery project gained from the waste disposal standpoint, the State and other private downtown developers were attracted to a waste-to-energy system concept because of the projected lower energy costs and the elimination of air pollution abatement responsibilities fror their antiquated boilers. Shortly after initial contracts were made with potential customers, it was suggested that solid waste be used as the fuel source in lieu of conventional fossil fuels. When they reacted

favorably to the idea, the way was cleared for serious planning to take place for a full scale resource recovery project.

The project's initial organization grew out of the Mayor's commission to investigate the development of a Nashville district heating system. This occurred shortly after the Nashville city government consolidated with that of Davidson County to form Metro. The Mayor and City staff viewed the project as an opportunity to demonstrate the problem-solving capability of the new regional government.

Since the effort became part of an overall urban renewal commitment, the participants in the project included representatives from the Law Department, Finance Department, Regional Planning Office and the Urban Renewal Agency in addition to the Director of Public Works.

Faced with serious time constraints for instituting and organizing financial support, the officials involved felt that the most expedient means of organizing and financing the project would be through the establishment of a separate non-profit corporation, Nashville Thermal Transfer Corporation. Once Thermal was established, the project's development was able to proceed in a streamlined manner.

The establishment of a successful resource recovery facility hinges on the development of a series of long term contracts. Typically, the two most critical contracts involve guarantees for the amount of waste entering the facility and market agreements for the energy products.

Thermal was able to successfully negotiate 13 steam and 12 chilled water service contracts covering 28 buildings over the past 10 years. The key contractual provisions follow:

- Maximum demand for heating and/or cooling.
- Exclusive supply of heating/cooling by Thermal.
- Emergency disruption provisions without payment of damages.
- Necessary rate adjustments to fulfill bond covenants.
- Typically a thirty year contract lifetime.

The customers include City and State office buildings, as well as banks, hotels and commercial office complexes. Among these are six buildings representing an investment of over $90 million which have been constructed with no independent heating or cooling capacity.

For the buildings on the loop, Thermal has provided all heating and cooling needs, continuously, 24 hours/day, 365 days/year for the past six years.

favorably to the idea, the way was cleared for serious planning to take place for a full scale resource recovery project.

The project's initial organization grew out of the Mayor's commission to investigate the development of a Nashville district heating system. This occurred shortly after the Nashville city government consolidated with that of Davidson County to form Metro. The Mayor and City staff viewed the project as an opportunity to demonstrate the problem-solving capability of the new regional government.

Since the effort became part of an overall urban renewal commitment, the participants in the project included representatives from the Law Department, Finance Department, Regional Planning Office and the Urban Renewal Agency in addition to the Director of Public Works.

Faced with serious time constraints for instituting and organizing financial support, the officials involved felt that the most expedient means of organizing and financing the project would be through the establishment of a separate non-profit corporation, Nashville Thermal Transfer Corporation. Once Thermal was established, the project's development was able to proceed in a streamlined manner.

The establishment of a successful resource recovery facility hinges on the development of a series of long term contracts. Typically, the two most critical contracts involve guarantees for the amount of waste entering the facility and market agreements for the energy products.

Thermal was able to successfully negotiate 13 steam and 12 chilled water service contracts covering 28 buildings over the past 10 years. The key contractual provisions follow:

- Maximum demand for heating and/or cooling.
- Exclusive supply of heating/cooling by Thermal.
- Emergency disruption provisions without payment of damages.
- Necessary rate adjustments to fulfill bond covenants.
- Typically a thirty year contract lifetime.

The customers include City and State office buildings, as well as banks, hotels and commercial office complexes. Among these are six buildings representing an investment of over $90 million which have been constructed with no independent heating or cooling capacity.

For the buildings on the loop, Thermal has provided all heating and cooling needs, continuously, 24 hours/day, 365 days/year for the past six years.

Since Metro is responsible for solid waste collection and disposal in the region, Thermal needed only to contract with one government agency to secure its waste supply. The contracts with Metro are covered under three agreements signed between 1971 and 1975. The key issues include:

- For 30 years, Metro will make its maximum amount of refuse collected (or coming into its possession) available to Thermal.
- Raw waste sizing and special materials concentrations will be limited by Metro.
- Metro will receive the ash byproducts and other residuals for ultimate disposal.
- Metro agrees to make an annual payment of up to $1,500,000 for the waste processing services provided by Thermal until long term financing has been covered. Thermal will charge no direct tipping fees to Metro.

Subsequent to the creation of Thermal, a local Architect/Engineer (A/E) was employed to provide plans, specifications and technical assistance for constructing the proposed central heating and cooling system. Firm contract bids for the cost of the material, and installation of the distribution system, boiler plant, and chilling plant were obtained.

Since the distribution system bids were taken at the same time as the Nashville Housing Authorities (NHA) work with respect to the urban renewal program in the central business district, it is estimated that almost $2,000,000 of costs for road excavation, trees, curbing, and repaving which were funded by NHA, were saved from the construction costs borne by Thermal.

The Nashville project ultimately evolved into a relationship between Thermal, as owner/operator; Metro, as waste supplier; and the energy users on the steam/chilled water loop. The chronology of events leading to the project's current status is presented in Exhibit 3A.

EXHIBIT 3A

NASHVILLE CHRONOLOGY

Date	Event
1969	Urban Renewal feasibility study
1969	District Heating feasibility study
1970	Solid Waste Fired District Heating Plant studied
1972	$16.5 Million Revenue Bonds floated
1972	Construction began
1974	Operation begins, air pollution problems start
1975	Metro increased Disposal Fees
1976	Additional $8.0 million Bonds/Loan granted
1976	First Electrostatic Precipitator operational
1977	Second Electrostatic Precipitator operational
1979	E.S.P.'s pass air pollution tests
1979	10% Rate increase (first since 5/75)
1980	Gross operating revenues of $2,969,273 ($25/ton)
1980	91.2% of fuel requirements satisfied by Solid Waste

Technology

Like most resource recovery systems, the Thermal facility is a dual purpose plant: a municipal solid waste incinerator and a central heating and cooling plant. The solid waste disposal system consists of a central processing facility served by transfer stations strategically located throughout the service area, with the energy system consisting of the same central power facility connected to an energy distribution pipe line.

A cross-section of the central facility is shown in Exhibit 3B. A 5400-cubic yard refuse pit provides three days fuel storage for the furnaces. A crane picks up the solid waste and feeds it continuously into multi-level 12-foot wide reverse reciprocating grates, manufactured by the Detroit Stoker Company.

Ash from the incinerator is dropped into an ash hopper and sprayed with water to cool the ash and eliminate dust during the ash removal and disposal process.

Combustion air, drawn into the plant through the solid waste storage room, consumes any odors generated in the receiving pit area.

The energy system is based on two 360-ton per day boilers, manufactured by Babcock and Wilcox Company. For maximum heat recovery, the flue gases exit the boiler sections through an economizer bank wherein the temperature of the gases are reduced to approximately 500°F.

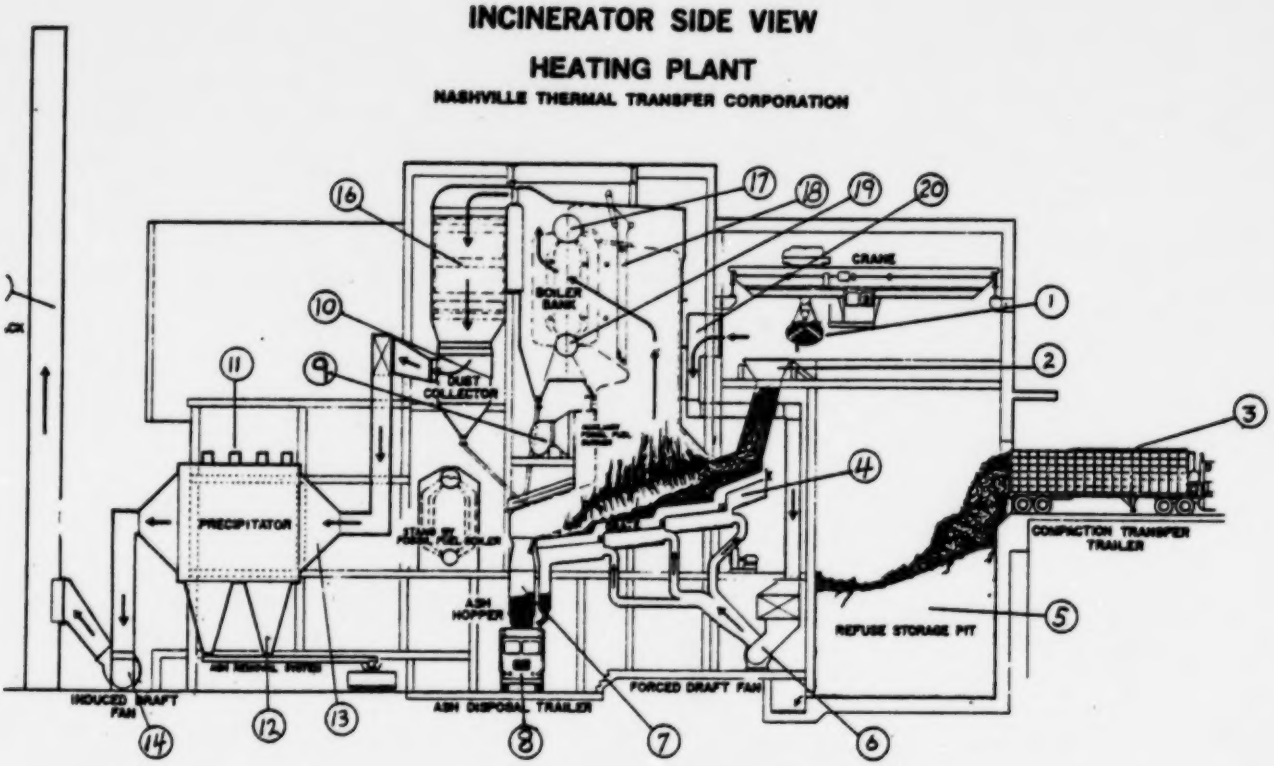
The electrostatic precipitators were manufactured by American Air Filter and installed in 1976 and 1977 to replace inefficient dust collector and wet scrubber systems. Particulate emissions on five certified tests ranged from 0.0068 - 0.0103 grains per standard cubic foot corrected to 12% CO_2 (the current EPA standard is 0.08 grains per SCF). With the exception of wintertime vapor plumes, the stacks usually contain no visible emissions.

For heating purposes, steam—at 400 pounds pressure and 600°F—goes directly from the boilers into non-condensing steam turbines and then into the distribution network. For cooling, steam generated in the boilers is piped to non-condensing turbines to power two Carrier Corporation chillers, each rated at 7,000 tons of cooling capacity.

Two cooling towers dissipate the heat from the chilled water cycle. Each Marley Company tower has a water capacity of 90,000 gallons and a recirculating water rate of 17,000 gallons per minute. At full load, when both chillers and boilers are operating at capacity, the plant has a makeup water requirement of approximately 1,500,000 gallons per day.

EXHIBIT 3B

CROSS-SECTION: NASHVILLE THERMAL'S
CENTRAL FACILITY



1. CRANE
2. CHARGING HOPPER
3. SOLID WASTE COMPACTOR TRAILER
4. FOUR LEVEL RECIPROCATING GRATES
5. SOLID WASTE STORAGE PIT
6. FORCED DRAFT FAN
7. ASH HOPPER
8. ASH DISPOSAL TRAILER
9. AUXILIARY BURNER
10. DUST COLLECTOR
11. PRECIPITATOR POWER SUPPLY
12. ASH REMOVAL SYSTEM
13. ELECTROSTATIC PRECIPITATOR
14. INDUCED DRAFT FAN
15. STACK
16. ECONOMIZER
17. TOP OR STEAM DRUM
18. SUPER HEATER
19. LOWER DRUM
20. FORCED AIR INLET

Steam and chilled water (at 41°F) are carried by a 3 mile long pipeline under city streets through a four-pipe distribution system. Condensed steam and spent chilled water (at 57°F) are returned to the district plant in closed recirculating cycles.

Facility Economics

The facility's capital costs are displayed in Exhibit 3C. The additional 1976 capital costs were due to the installation of electrostatic precipitators plus $3.9 million in deficits incurred during the first one and a half years of operation. The projected 1980 costs for this system, escalated using Marshall and Swift Cost indices, are approximately $40,015,000 or $286/ton.

The initial defecits led to two rate increases in 1975. Although steam and chilled water rates were increased by 191% and 69% respectively to cover revenue shortfalls, in the four and a half years between 1975 and 1979, when there was considerable energy price instability in the country, Thermal rates remained constant. In December 1979 a 10% rate increase was enacted. Increases in the future are expected to raise at a much slower rate than those of competitive energy sources.

Preliminary estimates of the facility economics project heating and cooling costs savings of 25 - 48% through the use of a resource recovery facility. Although these savings were not realized, Thermal has been competitive with other sources of energy.

The existing steam rates average approximately $6.00/1000 lbs. and the chilled water rate is approximately 8.0¢/ton-hour. The Annual Statement of Revenues and O & M Expenses for 1980 is shown in Exhibit 3D. In addition to the major energy revenues, the recent annual payment from Metro to Thermal for waste disposal (tipping fees) was $1,300,000 or $9.30/ton.

When considering the facility's economics, it is important to note that Thermal presently sells only 60% of the energy it produces. The remaining 40% is considered to be the amount of excess capacity required to assure continued service during periods of peak demand. Therefore, excess revenue generating potential exists if markets could be located within reach of the distribution system.

Since its startup in 1975, Thermal has disposed of over 850,000 tons of solid waste and replaced approximately 1.5 million barrels of oil. Heating and cooling service has been provided without interruption for six years to customers on the loop, including

EXHIBIT 3C

CAPITAL COST ELEMENTS OF NASHVILLE THERMAL

Direct Construction Costs		
Heating Plant	$ 5,454,813	
Chiller Plant	$ 2,903,213	
Total Incl. Sales Tax	$ 8,358,026	
Less reduction in Sales Tax for pollution abatement	117,409	
Net Cooling/Heating Plant Construction Cost	$ 8,240,617	
Net Distribution System Cost	$ 3,988,301	
Site Acquisitions (7 Acres)	250,000	
Site Preparation	50,000	
Engineering Services	611,446	
Contingencies and Miscellaneous	576,636	
Total Direct Construction Costs		$ 13,717,000
Indirect Costs		
Debt Service Reserve Fund	$ 990,000	
Capitalized Interest	1,980,000	
Legal Fees	62,000	
Financial and Administrative Fees	330,000	
	$ 3,362,000	
Less, Interest Earned During Construction	597,000	
Total Indirect Construction Costs		$ 2,783,000
Total Capital Cost Requirement (1972 Bonds)		$ 16,500,000
Other[1]:		
1976 Bonds Issued		$ 2,295,000
1976 State Loan		$ 5,705,000
Total		$ 24,500,000
Total Capital Costs in 1980 Dollars		$ 40,015,000

1. Major Expenses during startup included two new Electrostatic Precipitator Units.

EXHIBIT 3D

NASHVILLE THERMAL FINANCIAL REVIEW (1980)

Revenue Elements			
Energy Related:			
Steam Service		$ 1,555,401	
Cooling Service		$ 1,413,872	
			$ 2,969,273 ($21.21/ton)
Other:			
Payment from Metro		$ 1,300,000	
Interest Income		240,297	
Entitlements		590,411	
Other		6,184	
			$ 2,136,892 ($15.26/ton)
Total Income			$ 5,106,165 ($36.47/ton)
O & M Costs			
Production		$ 2,395,670	
Distribution		35,359	
Admin. and General		344,853	
			$ 2,775,882 ($19.83/ton)
Debt Service Requirement			$ 2,005,554 ($14.33/ton)
Total Costs			$ 4,781,436 ($34.16/ton)
Funds available for reducing fund deficit			$ 324,729

six buildings that are without backup boiler and chiller systems. Since 1978, over 90% of the steam/chilled water energy requirements for the Thermal system were satisfied by solid waste. Thermal's goal of employing solid waste for 95% of total boiler fuel needs should continue to keep its energy costs attractive and increase fuel costs less rapidly than fossil fuel fired systems.

Lessons Learned

Nashville's initial operating problems and the solutions to these problems provide revealing examples for other resource recovery projects.

To begin with, although Nashville's waterwall technology was touted as proven, in reality it employed relatively untried American engineering rather than the more off-the-shelf European version. The fact that this made Nashville's system somewhat of a pilot system was a direct cause of several operating problems. First, and most importantly, Thermal's engineers had no prior cost examples on which to base estimates. Consequently, their cost projections fell far short of reality. This had the effect of significantly under-financing the Thermal project which led to many equipment and design "short-cuts". Problems with corrosion in the waterwall tubes could also be linked to inexperience with solid waste combustion although last minute cost-cutting measures also contributed to this failure.

Nashville's rush to implement a system was an additional factor in their initial problems. The resource recovery project was hurried by the desire to take advantage of the other urban renewal projects occurring simultaneously. This tme constraint caused Metro and Thermal to spend insufficient time examining all of the alternatives. One result of this haste was the nearly disastrous decision to choose low energy wet scrubbers for air pollution control.

Nashville's current operating "success" is testimony to the determination of the Metro and Thermal officials involved, as well as to the security provided the system by its original contractual arrangements. Despite the initial problems, Thermal continued to receive wastes from Metro and revenues from its energy customers.

After having inital optimistic claims thrown back in its face, Thermal today is much more low-key, shunning publicity and quietly going about its business of waste disposal while slowly but surely achieving the goal of providing low cost energy to its customers. The proof of its success is that Nashville is actively investigating the implementation of another Thermal-type system.

NASHVILLE REFERENCES

Consulting Engineers of Tennessee, Inc. "Nashville Incinerator with Heat Recovery and the Compatible Central Heating and Cooling Facility". November, 1973.

Heidenreich, Peter E. "Nashville Thermal Transfer Corporation: A Status Report". Presented at the International Public Works Congress and Equipment Show, New Orleans, Louisiana, September 20-25, 1975.

Heidenreich, Peter E. Public versus private solid waste management: The Nashville approach. Solid Wastes Management, May 1978.

Kirkpatrick, Milton E. "Update on Nashville Thermal". In: Proceedings of the National Waste Processing Conference, Washington, D.C., May 8-11, 1980.

McEwen, Laurence B., and Steven J. Levy. Can Nashville's story be placed in perspective? Solid Wastes Management, August 1976.

R.W. Beck and Associates. "Annual Survey and Report: Nashville Thermal Transfer Corporation, Nashville, Tennessee", May 31, 1978.

Ibid. May 31, 1979.

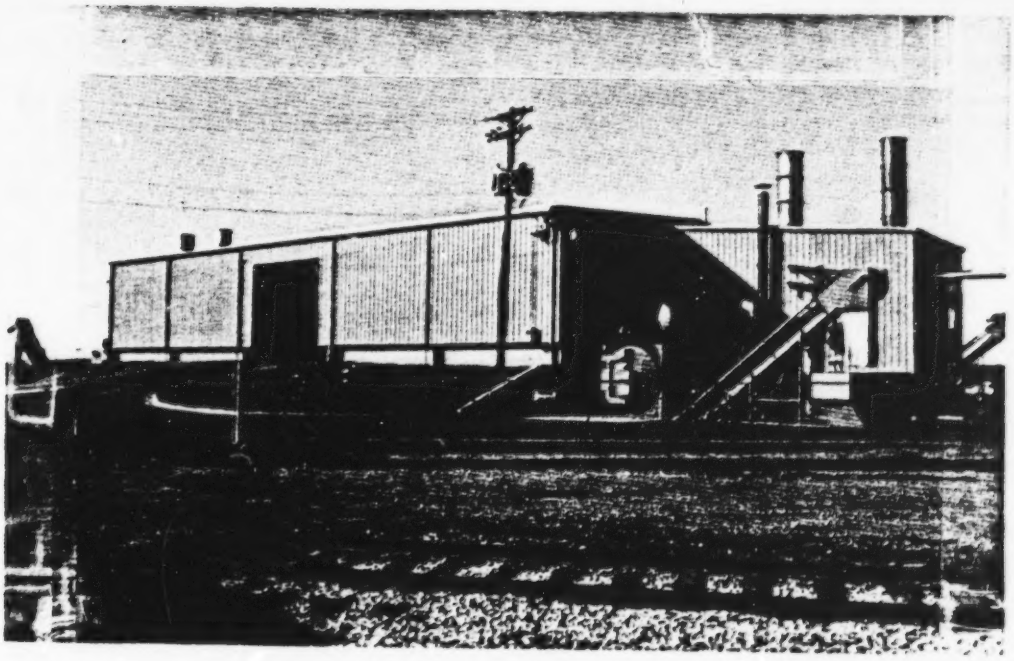
Swinehart, Glenn A., and Whitney A. Sanders III. Waste-to-energy: Applying the technology in the real world. Solid Wastes Management, May 1979.

Thermal. Undated. Public relations brochure of the Nashville Thermal Transfer Corporation.

U.S. Conference of Mayors, Institute for the Development of the Urban Arts and Sciences. "Nashville: A Case Study of Economic Development and Resource Recovery". March 1980.

CHAPTER 4

NORTH LITTLE ROCK, ARKANSAS



Introduction

Since the fall of 1977, a 100 ton per day modular incinerator has been supplying energy to a local industry and providing waste disposal for this town of 65,000 people in mid Arkansas. This facility is significant in the history of resource recovery in the U.S. in that it was the first modular incinerator with energy recovery to be operated on a continuous feed (24 hrs/day) basis. This represented an important development because it enabled small capacity systems to meet industrial energy market demands for a reliable, continuous supply of energy.

The system represents the first generation of this type of modular incinerator. As with any first generation facility it has experienced problems, some of them serious, in its brief operating history. What qualifies the system as a success is the manner in which the problems have been overcome to result in a facility which continues to meet the needs of the community and industry.

Driving Forces

As is typical with resource recovery facilities that have been built to date, the general impetus for implementing the system was two-fold: the community was facing problems with continued landfilling; and a local industry was actively seeking an inexpensive and reliable alternative to fossil fuel based energy.

The city itself generated around 70-80 tons of solid waste per day, all of which was collected by the Department of Public Works. However, the city owned and operated landfill was forced to shut down, and the closest private landfill was 12 miles away. The city was reluctant to incur the additional transportation costs and to face the privately dictated tipping fees associated with that landfill. Their investigation of new landfill capability revealed public resistance and lack of suitable land. These factors led to the City's decision to implement a solid waste incinerator.

Although the above solid waste disposal problem was a contributing factor, the project would probably never have been implemented in its present form if it had not been for the implications of the natural gas shortage which occurred while the City was debating its solid waste options.

Prior to the winter of 1976-77, the State and Federal Power Commissions informed their low priority gas customers that they faced a possible ninety day curtailment of gas supply during the following winter. It was anticipated that the shortage would temporarily shut down all industries without dual capacity boilers. This affected most industries in the state, including Koppers Industry's Forest Products Division, one of the largest private employers in North Little Rock.

This severe shortage of natural gas created an environment in which State and local officials were eager to join with private industry to develop alternative energy sources. Resource recovery was recognized as having tremendous potential for immediate impact and was encouraged by State regulations. The Arkansas Public Service Commission in 1976 ruled that refuse was a "less scarce fuel" and thereby ordered an intrastate natural gas priority classification for resource recovery facilities. For any "incinerator heat recovery system" which demonstrated net energy savings, the State sought to assure that sufficient natural gas was available for start-up and back-up uses.

The generally persuasive considerations discussed above can be summarized into three key factors leading to implementation: first, city officials saw resource recovery as part of a larger solid waste management strategy which could be employed to raise revenues via user charges and steam sales, thus reducing the burden of raising revenues via the property tax. Second, given the natural gas crisis in Arkansas, the project was

expected to give the City a competitive edge in attracting new industry (the recovery facility site is located adjacent to a vacant industrially-zoned tract owned and promoted for development by the Missouri Pacific Railroad). Third, the resource recovery project would help the city retain its third largest private employer.

As indicated earlier, problems with conventional solid waste disposal played a role, but not the critical one in the decision. When planning for the resource recovery facility in 1976, the City was well aware that tipping fees at the existing landfill (then $3.00 per ton) would be significantly lower than those at a recovery facility. However, the economics of rising transportation costs, projected revenue from the sale of steam, and less road system wear outweighed these narrowly defined economic comparisons of tipping fees alone. In view of this and the previously mentioned energy conservation factors, the City decided to proceed even though the comparison of existing tipping fees did not justify continued development.

Project Organization

Actual implementation of the system required the coordinated interaction of a number of disparate participants.

The key role in the project's initial development was played by Consumat's local sales representative, U.S. Recycle. First, U.S. Recycle aided the City in performing the necessary feasibility studies and analyses required to assess various City alternatives. To comply with State requirements, they expanded upon a comprehensive solid waste disposal plan previously prepared for the City. Secondly, U.S. Recycle identified Koppers as a potential energy market and suggested that Koppers lease the site to the City for construction of the facility. Finally, as a vendor experienced in similar project development, they assisted the City in developing a viable financial package and in supervising the plant's construction and first year operations.

Many of the institutional barriers that have confronted other resource recovery facilities were avoided by the City, which took full advantage of the private sector's experience in project development. U.S. Recycle was able to occupy a somewhat unique position of trust and confidence with the City primarily because of its demonstrated experience within the State. U.S. Recycle had already negotiated energy recovery systems with Siloam Springs and Blytheville, Arkansas.

As described above, U.S Recycle developed initial interest and helped demonstrate overall feasibility, but by 1975 it was time for strong public leadership to become involved in order to sustain momentum and obtain the commitments necessary to proceed.

In North Little Rock's case, this central leadership was supplied directly by the Mayor's Office. Fortunately, the City was not considering bringing in waste from other communities so no special regional administrative frameworks were necessary. The City simply planned to own and operate the system essentially like any other public works project, with several significant differences. The differences relate to the business aspects of a resource recovery facility, i.e. the need for raw materials (solid waste), and the need for a market for the recovered energy product (steam in this case).

For North Little Rock, the potential problem of securing the waste supply was essentially eliminated by the fact that the City collected enough waste (70-80 TPD) to supply the facility on its own. The facility was ultimately designed to accept 100 TPD to provide adequate back-up capacity as well as to assure meeting the market's energy demand. The additional waste was expected to come from commercial waste that was privately collected within the City. The original waste control strategy was to keep tipping fees competitive with landfills in the area so that additional waste supply could be attracted on the basis of "marketplace" economics.

The other significant difference involved the sale of recovered energy to an industrial market, the Koppers Company. Koppers' involvement in the North Little Rock project is a reflection of the company's nationwide energy policy. Company policy openly states that Koppers plants develop alternative energy sources. In two other facilities, Koppers uses biomass and wood chips for energy production.

Koppers' North Little Rock plant is the Forestry Products Division which employs 85 people in the manufacture of creosoted railroad ties. As previously noted, in 1975 Koppers was aware of the potential shortage of natural gas and as early as 1974 was seeking alternative energy sources. In 1974, U.S. Recycle approached Koppers with the prospect of a reliable, non-gas based, energy supply at a discounted price. By late 1975 the City had become involved in the project and an agreement in principle was reached between the City and Koppers. This led to the eventual 20-year contract for sale of steam which was signed in mid 1976.

In general, the contract reflects the City's desire to offer a very favorable arrangement to one of its largest employers and tax payers. Although Koppers agreed to purchase as much steam as it needed through the life of the contract, it did not guaranteee any minimum purchase. A "take-or-pay" market agreement was thought to be unnecessary due to the long-term commitment of Koppers to remain in the area. Conversely, the steam agreement obligates the City to supply minimum amounts of steam to Koppers. Koppers is protected against any unplanned interruption of steam service by maintaining its own boilers on standby. If for any reason Koppers is forced

to burn fossil fuel in its boilers, the cost of the fuel is deducted from the steam payment to the City. If an alternative energy source becomes available to Koppers at a lower rate than steam, Koppers can be released from the steam contract within one year after proper notice is given to the City.

The base price of steam was pegged to the lowest fuel available to the Forest Products plant (natural gas or acceptable fuel oil). The price of steam per 1,000 pounds is to be discounted. The discount ranges from a low of four percent (when the base price of the lowest cost available fuel is $0.81 per million Btu) to a high of 30 percent (when the base price exceeds $2.90 per million Btu). Currently, Koppers is paying around $2.50/1000 # which includes a 22% discount.

In addition to having a reliable energy supply at a discounted price, Koppers was able to save on the capital costs of converting boilers to cofire oil. Koppers had anticipated the need to convert all three of their boilers to cofiring of oil. The resource recovery facility made it necessary for Koppers to convert only two.

Koppers agreed to lease the site for the facility on a 20 year basis for $1 per year. This arrangement was beneficial to the project not only from an economic point of view, but also because it alleviated much of the public resistance which is typicaly associated with siting a waste disposal facility.

One other aspect of the contract with Koppers is worth noting. Koppers insisted on the right to approve the final plans and specifications for the project, including the contractor(s) ultimately selected.

The system procurement process for the North Little Rock facility had several unusual aspects. Arkansas State Law required the City to take competitive bids in a conventional A & E type procurement. In accord with the conditions of the steam contract, the City agreed to allow Koppers to include several requirements in the RFP itself. Koppers used these criteria as the basis for rejecting the lowest bidder on the grounds that technical specifications were not met. After several months of negotiations, the City, with Koppers' approval, awarded the contract to U.S. Recycle (Consumat). However, the rejected lowest bidder sued the City which resulted in several months delay and nearly undermined the initial bond sale.

In 1979, the City's inability to operate the system forced it to seek operating assistance from the private sector (more will be said about the causes of the City's operating problems in the Lessons Learned Section). A RFP for system operation was issued, and Consumat was subsequently awarded the contract. Consumat effected the necessary repairs and has been operating the system since May 1980.

The general chronology of the events described in this section is presented in Exhibit 4A.

EXHIBIT 4A

NORTH LITTLE ROCK CHRONOLOGY

Date	Event
1971	City buys two 12.5 TPD Consumat modular incinerators
1974	City officials set long range Solid Waste Management goals
1975	U.S. Recycle Study on Solid Waste Management
1976	Natural Gas crisis
1976	Koppers and North Little Rock Contracts signed, subjects include: - steam purchase (20 years) - site lease ($1 per year cost to City)
1976	$1.3 million special revenue bonds issued
1976	Construction begins
1978	Operation begins
1979	Plant closed by Mayor for repairs
1979	City and Consumat sign operation contract; repairs begun
1980	Plant begins operating again under Consumat's operation

Technology

The North Little Rock facility is a small-scale, modular combustion system. By now, this technology has been described often enough so that it is generally well understood. Accordingly, the description presented here is brief.

The system is designed for processing municipal solid waste at a rate of 100 tons per day, five days per week. Energy is recovered in the form of steam. The facility is equipped with four controlled-air modular combustion units, each having a capacity of 25 tons per 24-hour day. These are paired with two boiler heat exchangers each capable of producing 10,000 pounds of steam per hour at 150 psig. The equipment is designed and manufactured by Consumat Systems, Inc. In addition, a dual-fuel package steam boiler is provided in order to assure steam production in the event one unit is down. Each controlled-air combustion unit is equipped with an automatic ash removal and a wet ash conveyor system, but ash may be removed manually if necessary.

The controlled-air modular combustion units are designed to burn batch-fed refuse in an air-starved environment at an automatically controlled rate of burn. Incoming residential and commercial refuse is dumped onto the floor of the plant in front of each pair of units where it is moved alternately by small tractors to an automatic ram-type loader for each incinerator. Following batch charging of each unit, refuse is volatized by partial oxidation in a cylindrical lower chamber. The combustion process is a combination of pyrolysis, volatization, and gasification of hydrocarbons, in addition to the small amount of burning that occurs. The process is controlled to maintain extremely low gas velocities in the lower chamber. Gases from the lower chamber pass into an upper chamber, or pollution control chamber, where they are ignited by an after burner. As a result, very fine and hot smoke particles entrained in the gases from the lower chamber are oxidized rapidly in the upper chamber thus producing very low stack emissions.

The hot gases (1500°F - 1800°F) from the upper chamber are directed by a blower and an aerodynamic valve to either a dump stack or to a smaller stack where a boiler heat exchanger is located. The system's boiler is of the fin-tube design and is much smaller than most waste-heat boilers. In the event of a power failure or the need to shut off the blower, flue gases are directed up the dump stack and into the atmosphere. (Partial steam production also can be achieved by directing hot gases partially up the dump stack). According to the results from EPA sponsored testing of the system in 1978 the overall system's energy efficiency (output steam/input energy) was 56%.

Steam is produced 24-hours per day on at least a 5-day per week basis. The Koppers plant maintains its existing boiler capacity on a stand-by basis. Koppers also returns any condensate to North Little Rock for preheating make-up water.

Because of the firing of gases in the upper chamber, visible emissions occur only infrequently. The high temperature burning of gases in the upper chamber also eliminates any emission of detectable odors. Thus, the modular combustion unit design apparently addresses the undesirable characteristics generally associated in the public's mind with incinerators.

The EPA tests conducted in October 1978 indicated that the facility's average particulate emissions were .130 gr/scf (corrected to 12% CO_2) which is within the .2 gr/scf limit established by Arkansas law. The facility does not emit 100 tons per year of any pollutant so the Federal .08 gr/scf standard does not apply.

Residue from the combustion process averages about 5% by volume and 38% by weight compared to incoming waste. The residue is disposed of in a private landfill.

Economics

The North Little Rock facility has cost a total of $1,724,000 to date. This amount was financed through a variety of means. The City had previously purchased but never installed two non-energy recovery Consumat incinerators in 1971 for $147,000. This money was raised through sale of General Obligation Bonds. When the current resource recovery system was purchased from Consumat in 1975, U.S. Recycle agreed to accept a trade-in of the un-used incinerators and credit the City for the $147,000.

The majority of the system's costs (1.3 million) were financed through the sale of special revenue bonds which are considered special obligations of the City, but are not backed by the "full, faith and credit" of the City. The principal and interest are covered by rates or service charges imposed for the collection and disposal of refuse.

The remainder of the system's original cost ($77,000) was covered by monies from the City's general fund. This financing scenario is presented in tabular form in Exhibit 4B.

As shown in the Exhibit, Consumat contributed around $200,000 in 1979 to repair and upgrade the system. By applying Marshall-Swift cost indices the total cost of the current system in 1980 dollars can be estimated at $2,310,000.

Current operating economics are shown in Exhibit 4C. The figures shown are for the first full year of operation since Consumat took over. They are actual numbers and not projections (although some are estimates based on unaudited data). Detailed

EXHIBIT 4B
NORTH LITTLE ROCK CAPITAL COST BREAKDOWN (1975 DOLLARS)

Direct Construction Costs	
4 CS - 1200 Combustion Units w/2 Waste Heat Boilers	$ 872,000
Construction and Installation	$ 411,000
Indirect Construction Costs	
Financing, Start-up, Contingencies and Reserve Funds	$ 241,000
TOTAL INITIAL CAPITAL COSTS	$1,524,000
(Less trade-in value of 2 previously purchased but unused Consumat units financed by 1971 G.O. Bonds)	$ 147,000
ADJUSTED TOTAL INITIAL CAPITAL COSTS	$1,377,000
(Financed by $1.3 million special revenue bond sale and $77,000 in city general funds.)	
Additional Costs (1979 dollars)	
Repair and upgrading (paid by Consumat)	$200,000
TOTAL SYSTEM CAPITAL COSTS IN 1980 DOLLARS	$2,310,000
(Using Marshall Swift equipment indices)	

EXHIBIT 4C

NORTH LITTLE ROCK FINANCIAL SUMMARY
(May 1980-April 1981)

Tons of Solid Waste Processed[a]	
North Little Rock	18,720
Others	5,980
Total	24,700

	Cost/Revenues to City		Cost/Revenues to Consumat	
	Total Annual (1000's)	$/Ton[b]	Total Annual (1000's)	$/Ton[c]
Operating Revenues				
City "Tipping Fee"	-	-	185	-
Other Tipping Fees	-	-	30(d)	8.70
Steam Sales	240	12.82	-	-
Total Revenues	240	12.82	215	8.70
Operating Expenses				
Operating Fee	185	9.88	-	-
Personnel	-	-	139	5.63
O & M	-	-	92	3.74
Admin. & General	-	-	22	.87
Subtotal Operating Costs	185	9.88	253	10.24
Debt Service	130	6.94	-	-
Total Costs	315	16.82	253	10.24
Net Cost to Participants	75	4.00	38	1.54

NET COSTS OF SYSTEM[e] $143,000/Year
$5.78 /Ton

(a) Based on 95 tons/day, 260 days/year (Actual average for 11 months of Consumat data - 94 tons/day), 72 tons/day - City, 23 tons/day - others.
(b) Based on City's tonnage only (18,720).
(c) Based on total tonnage (24,700).
(d) Based on $1.25 cu/yd of truck capacity ($5/ton).
(e) Based on Consumat's operating costs, plus debt service less steam sales revenue, divided by total tonnage.

information for previous years, when the City operated the system was not readily available.

The information in Exhibit 4C is presented in two categories, one pertaining to the City's costs and revenues and the other to Consumat. This has been done to show the operating economics in terms of the economic interrelationship that now exists between the owner and operator. It can be seen that, although the City paid Consumat an operating fee that amounts to $12.82 per ton, its actual costs per ton were only $4 because it receives all of the steam revenues. Conversely, under this first year's arrangement, Consumat receives a tipping fee equivalent to $8.70 per ton of refuse received (12.82/ton from the City; $5/ton from private haulers), but has operating costs amounting to $10.24 per ton. This resulted in a net loss to Consumat of $1.54 per ton during the first year. Consumat agreed to this arrangement because they wanted to win the contract to operate the facility and they were willing to risk taking a loss in order to ensure their selection. According to a Consumat representative, in the upcoming negotiations for the next year's contract the operating fee will be adjusted so that Consumat will not have to absorb a loss.

The final entry in the Exhibit (NET COSTS OF SYSTEM) is intended to show the costs of the generic system, regardless of the specific participants involvement.

This computation indicates that, if the system were owned and operated by one entity, the break-even tipping fee would be $5.78 per ton.

Lessons Learned

North Little Rock's operational and management experience with the Consumat facility offers a good example of the precautions a municipality should take while operating a resource recovery plant. The operation of high technology facilities requires technical and management expertise and proper attention to routine maintenance procedures.

The City of North Little Rock experienced several unfortunate operational problems. From the beginning of operations in September, 1977 to November, 1978, the plant operated at full capacity and supplied Koppers with 95% of its total steam needs. A few months after U.S. Recycle left the project (having fulfilled their start-up obligations), steam output declined and Koppers was forced to start using one boiler as a backup to the Consumat plant. By May of 1979, conditions at the plant had deteriorated to the point where the Mayor was forced to close the facility.

Many of the operational problems stemmed from a series of management problems. The plant had ten managers in the space of 2 1/2 years, resulting in a lack of management and a slippage in operational procedures. Although plant operations often required 11-12 employees, the facility had only 7 or 8 on staff. Maintenance funds were not fully allocated by the City. As a cost saving measure, the City employed CETA trainees to operate the facility, but failed to give them proper training in plant and equipment operation. Without question, technical, operational difficulties forced the plant shutdown.

After assessing the City's operating capacity, the Mayor, in early 1980, determined that it was best for the City to contract with a private operator to run the facility. The City opened the operations contract for public bidding, and awarded the contract to Consumat. According to Consumat, since May 1980, when operations began again, up through April 1981 there have been no interruptions in service or unscheduled downtime.

The City's problems with public operation of the facility are reflective of the often overlooked need for qualified personnel to operate and maintain high technology systems. In view of this need, many system vendors, including Consumat, are now actively promoting full-service arrangements.

There are several other significant lessons to be gained from the North Little Rock experience.

- Reliable energy supplies from resource recovery can reduce industry's dependence on imported oil and gas, and may be used to retain, expand or attract industries, expecially where an area has suffered a severe shortage of the area's traditional energy supply;

- It is important to involve energy markets and system vendors in the project development as early as possible; and

- Designing a facility to provide for the waste of only one political jurisdiction can avoid many coordination difficulties which have plagued regionalization efforts of waste flows in this country.

NORTH LITTLE ROCK REFERENCES

City finds disposal solution: North Little Rock picks modular incineration for steam and income. Solid Wastes Management, March 1978.

Consumat Systems, Inc. "Energy-from-Waste Facility: North Little Rock, Arkansas".

Frounfelker, Richard E., and Ned J. Kleinhenz. "A Technical Evaluation of Modular Incinerators with Heat Recovery". In: Proceedings of National Waste Processing Conference, Washington, D.C., May 11-14, 1980.

Lirette, Ron. Consumat Systems Inc. Personal communication. April 9, 1981.

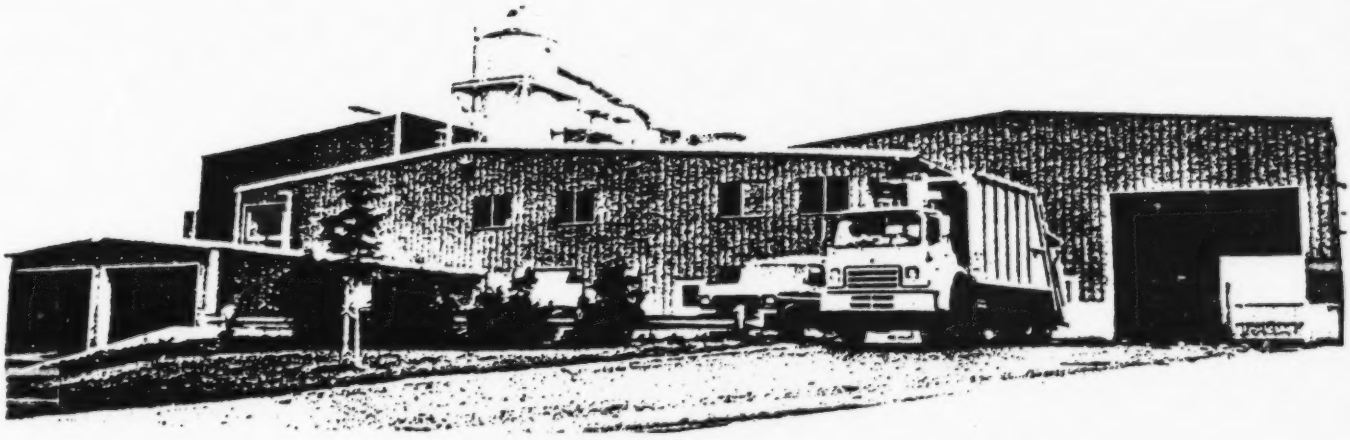
Lirette, Ron, Olinger, Tom, Sanders, Charles, and Gene Green. "Feasibility Study of Coincineration of Sewage Sludge and Municipal Waste". Conducted at North Little Rock Waste-to-Energy Plant by Consumat Systems, Inc. for the Department of Energy, May 8-10, 1979.

U.S. Conference of Mayors, Institute for the Development of the Urban Arts and Sciences. "North Little Rock: A Case Study of Economic Development and Resource Recovery". November, 1980.

U.S. Environmental Protection Agency. "The Resource Recovery Project of North Little Rock, Arkansas, Resource Recovery Project Implementation: Five Case Studies. 1977.

CHAPTER 5

MADISON, WISCONSIN



Introduction

The City of Madison and the Madison Gas and Electric Company (MG&E) are cooperating in a joint municipal solid waste (MSW) to energy system, which involves the production and use of refuse derived fuel (RDF). The RDF is produced by the City and co-fired with pulverized coal by MG&E in two Babcock and Wilcox suspension boilers, each of which drives a 50 magawatt (MG) electrical generator.

This system is included in this series because it is one of the few RDF facilities that is selling its product on a regular and reliable basis. An important factor in the success of the Madison system is the low ash content of the RDF produced, which makes it a more desirable fuel product. Unlike earlier RDF processing systems, Madison uses light shredding (flail mill) and rotating screens (trommel) to separate inorganic materials from the combustible fraction. Earlier systems used heavy shredders which tended to embed the inorganic (e.g., glass) in the combustible material. Subsequent processing steps, such as air classification, were unable to remove the embedded contaminants. This increased the ash content of the RDF. In addition, shredder intensive systems require high levels of maintenance and replacement as well as having an increased potential for explosion.

This system, like the others discussed in this series, is not without problems especially when viewed from the standpoint of economic viability. However, at this

point, the Madison Facility appears to offer a workable blue print for other small scale RDF facilities to follow.

Driving Forces

The City of Madison's experience with alternatives to conventional landfill disposal actually predates the RDF system. In 1967, the City began a test program of shredding solid waste prior to disposal as a means of conserving landfill space. This program was funded by a demonstration grant from Federal Government's solid waste program, which was part of the Department of Health Educaton and Welfare at that time. The project was later expanded to full-scale operation, handling all of the City's solid waste.

In the early 1970's the City began to look at energy recovery as a means of further reducing the demand for landfill space. A variety of factors led to the decision to employ RDF as the energy recovery approach. Perhaps the most important factors were the City's shredding experience and the markets requirements. At the time, shredding was considered an integral component of any RDF system and the City had extensive experience with this operation. Furthermore, MG&E expressed interest in the use of RDF as a supplemental fuel in its coal-fired power plant.

The shredding-landfill operation continued until it was replaced by RDF processing system in 1978. The shredding plant was then closed for removal of the existing equipment. Some of the equipment (conveyors, compactor) was salvaged for use in the new system. The previous year, the City and MG&E had signed a ten year agreement to produce and use RDF. Final approval was given by the City Council even though they were told landfill was the cheaper alternative. The decision was influenced by the fact that a new landfill would be required, which would encounter a great deal of public resistance, as well as by the fact that resource recovery was more in line with the environmentally conscious tenor of the times.

Project Organization

As with the driving forces, the organization of the Madison energy recovery project was shaped by the City's shredding/landfill experience (see Exhibit 5A). On the surface the relationships among the participants appear to be typical. The City operates all of the RDF processing system and owns most of it. The City sells the RDF product directly to MG&E, but recovered materials are sold through an intermediary.

EXHIBIT 5A

MADISON CHRONOLOGY

Date	Event
1967	Begin test of shredding MSW prior to landfill
1972	Ferrous metal recovery subsystem installed
1973	Initial discussion between City and MG&E about use of RDF
1974	Engineering feasibility study of RDF use by MG&E
1977	Agreement between City and MG&E to use RDF
1978	Shredding operation ceased; plan modification to processing facility begun
1979	Facility processing of MSW
1980	MG&E begins burning RDF

Waste supply is controlled by the City through public collection. However, the basis for these relationships is related to the City's previous shredding project.

An important facet of the shredding project was the addition of ferrous metal recovery in 1972. This subsystem was installed by Continenal Can Company (CCC) at their own expense. In the mid-1970's, CCC sold their system concepts to Combustion Engineering (CE), which still owns the rights to the Madison System. In contrast to CCC's active participation in the project, CE has never been directly involved with the City.

As a result of this, several CCC engineers left the company. These individuals played important roles in the development of the Madison project. One of them, Bob Grisemer, purchased the flail mill and the separator trommel from CCC. Grisemer formed Madison Magnetic Operations (MMO) to continue ferrous separation Madison.

MMO, under its agreement with the City, owns the magnetic separation equipment and paid for its installation. The City's plant crews operate and maintain the equipment and bill MMO; the City also receives 10 percent of the after-cost revenues from the sale of the metal. Madison Magnetic currently markets the metal to a steel mill in Chicago.

Another Grisemer company, Madison Solid Waste Fuel Company. (MSWF), owns the "separation unit"-the trommel. As with the magnetic separator, the company furnished the equipment and paid for its installation; the City operates and maintains the unit and bills the company.

The trommel was installed under a 10-year performance contract; it is guaranteed to process 50 tph of input with a minimum RDF output of 30 tph at a maximum of 15 percent ash content. The City pays MSWF an annual fee, plus a variable per-ton fee based on throughput.

Another unique aspect of the project is that the City, through its engineering department, designed the complete system. Specialized design assistance was provided by another former CCC engineer. The City also served as prime construction contractor. The fact that the City was willing and able to perform these tasks is directly related to the experience gained from the shredding operation. City employees at the shredding plant who were transferred to the RDF facility were taught all phases of the RDF processing system and many even helped to construct it. The City's operating crews also attended a three week long training course conducted at a local vocational - technical school. This contributed to a shorter shakedown period and more confident, capable operators.

The City's relationship with MG&E is relatively straight forward. As with any energy recovery system there is a contract between the two entities. MG&E has agreed to purchase RDF for 10 years at a price that is tied to the price of coal on a straight Btu equivalency basis.

Assuring the waste supply is also straight forward since most of the waste entering the system comes from City operated collection. Two small neighboring towns also contribute solid waste to the system. The system is currently averaging around 270 tons per day, but it is capable of processing a much higher throughput. However, surrounding communities are reluctant to participate in the system because the tipping fee is higher than at currently available landfills.

Technology

Processing of MSW to produce RDF and the combustion of RDF are the two stages of the Madison system, as is typical with any RDF project. RDF is produced at the City operated processing facility and then trucked to a MG&E electric power plant.

RDF Processing

The MSW is delivered to the processing plant where it dumped onto the tipping floor. Small front-end loaders are used to push the refuse into a two-foot deep pit that has a metal pan conveyor in the bottom.

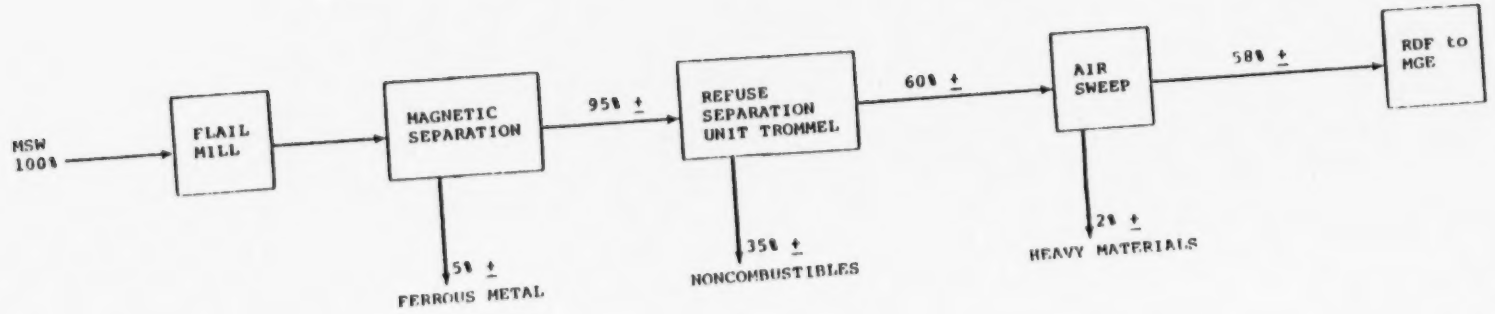
The first processing point in the system is the primary shredder, which is actually a flail mill, (see Exhibit 5B). The purpose of this initial shredding is primarily to open refuse filled plastic bags. The average particle size of MSW exiting the flail mill is eight inches. Madison has addressed the explosion problem by isolating the flail mill with reinforced concrete and masonry walls. In addition, blow-out panels have been installed in the roof.

Refuse leaving the flail mill is conveyed beneath a drum electromagnet, which removes the ferrous metals from the waste stream. Separated ferrous metals are upgraded through densification and removal of light contaminants by an air scrubber prior to shipment to a customer.

The non-magnetically separated materials are conveyed to a trommel for the next stage in the processing line. The majority of the remaining non-combustible materials, such as glass and grit, are separated from the combustible fraction in the

EXHIBIT 5B

FLOW DIAGRAM/MATERIALS BALANCE



trommel. These non-combustibles are taken to a stationary compactor for densifying and storage before landfill disposal.

Combustible materials exiting the trommel are conveyed to the secondary shredder. The objective at this point is to produce a material suitable for combustion in the MG&E boilers, which require three-fourth inch particle size.

Immediately upon discharge from the secondary shredder, the material enters an air chamber. This processing step functions both as a pneumatic transport system and as an air classifier. Heavy materials (e.g., wood, wet garbage) drop through the air stream to a stationary compactor prior to landfill disposal. The material remaining in the air chamber is blown into a cyclone and de-entrained; then it is conveyed to a transport trailer for transfer to the MG&E power plant approximately 3 miles away.

RDF Combustion

RDF is unloaded from a trailer into one of two storage bins (about 110 cubic yard capacity) at the MG&E receiving facility. These bins were designed to be small because storage of more than a few hours was not desired.

Each bin is equipped with an auger that feeds the RDF into a conveyor. The RDF then is taken to a flutter, air lock feeders, and pneumatically injected into the boilers.

The RDF is fed into each boiler from two refuse nozzles along with six coal nozzles. Because of a problem with burning refuse in the dry ash pit, drop grates were installed just above the pits to allow for combustion of the RDF that fails to burn in suspension. To aid in combustion, fans were installed for overfire and underfire air.

RDF supplies about 15 percent of the heating value of the normal fuel, which is pulverized coal. Since this MG&E plant is used for peaking power, the company requires a 60 percent load on the boilers before using RDF. Consequently, RDF is used only during high load periods, which amount to about 10 hours per day, five days per week.

Economics

Capital costs incurred by the City amounted to more than $3.9 million (see Exhibit 5C). This can be divided into two groups: $2.9 million for the processing plant; and $1.0 million for the receiving facility. MG&E also invested $0.5 million in modifications to their boilers, but Madison is reimbursing MG&E for this expenditure on

EXHIBIT 5C
CAPITAL COSTS

CITY OF MADISON

Processing Plant

Direct Construction Costs			
Building and Grounds		$1,024,976	
Process system[2]		1,259,183	
Indirect Costs			
Start-up, engineering		438,606	
	Subtotal	$2,722,765	

Receiving Plant

Direct Construction Costs			
Building and Grounds		282,065	
RDF feed system		544,471	
Indirect Costs			
Start-up, engineering		228,135	
	Subtotal	$1,054,671	
	TOTAL		$3,777,436

MADISON GAS AND ELECTRIC

Receiving Plant			
Boiler modifications		500,000	
	TOTAL		500,000
	GRAND TOTAL		$4,427,436
	GRAND TOTAL (1980 dollars)		$5,283,206

1. Cost data are in 1978 dollars, unless otherwise noted.
2. Excludes cost of ferrous metal recovery system and trommel device. Both units are privatel owned.
3. Cost datum escalated using the Marshall Swift equipment indices.

a five year payback schedule. The project was financed through 10 year bonds at 5.5 percent interest along with a small Community Development Block Grant. The total capital cost of the system is $5,283,206, when escalated to 1980 dollars using Marshall & Swift cost indices.

Exhibit 5D presents a summary of the system's annual economics for 1980. Costs for the RDF processing system and the MG&E receiving station are shown separately. As noted earlier the magnetic separator and the trommel are privately owned by Madison Magnetic Operation (MMO) and Madison Solid Waste Fuel Company (MSWF), respectively. The City bears the cost of operating these systems but then recovers a portion of the costs through charges to the owners. The City will receive a percentage of the revenues obtained from the sale of ferrous metal. However, MMO has not yet obtained sufficient revenues from metal recovery to warrant splitting with the City. In addition the City pays an annual fee to MSWF based on a sliding-scale throughput for the use of the trommel.

The revenues shown include the portion of the operating costs for the ferrous separator and trommel that are charged to MMO and MSWF. The net costs of the full system are $30.16 per input ton, and $26.42 per ton including the credits for DOE Entitlements. However, the entitlements program will be discontinued in September 1981. This amount is considerably higher than the $3.75 per ton tipping fee currently being charged for landfill disposal in the surrounding area. Despite this disparity, Madison feels that promising economic projections based on future energy revenues together with the environmental attractiveness of this approach justify the system's operation.

Lessons Learned

Two important lessons can be gained from Madison's experience with energy recovery. The first lesson is specific to the RDF approach to recovery. The solid waste processing system used at Madison has proven to be a major improvement in the production of RDF. Elimination of heavy shredding, as a first step in processing, significantly reduced the embedding of inorganic material in the combustible fraction. An important result has been a decline in the ash content of the RDF. In previous RDF systems, a high ash content has been a serious obstacle in developing markets. The experience to date in Madison demonstrates that RDF can provide a significant, reliable energy source for electrical utilities.

Secondly, Madison's experience illustrates that a system does not have to provide

EXHIBIT 5D
MADISON FINANCIAL SUMMARY (1980)

	Total	$/Ton[1]
Operating Expenses		
RDF Processing System		
Labor (not including hauling)	$287,936	$4.00
O&M	280,395	5.00
MSWF Payment	161,799	3.00
Hauling[3]	88,008	1.89
Debt Service	353,574	3.40
Subtotal	$1,171,712	$16.29
MG&E Receiving Station		
O&M	90,103	1.50
Debt Service	302,144	2.91
Subtotal	$392,247	$4.41
SUBTOTAL OPERATING EXPENSES	$1,563,959	$20.70
Operating Revenues		
RDF Sales	151,190	3.21
MSWF Charges	8,944	.19
MMO Charges	2,236	.05
SUBTOTAL OPERATING REVENUES	$162,370	$3.49
NET COST OF FUEL SYSTEM	$1,140,589	$30.16
Revenues From DOE Entitlements	173,601	3.74
ADJUSTED NET COST OF SYSTEM	$1,227,988	$26.42

1. Based on 46,474 tons of raw solid waste input to the system in 1980.
2. Hauling includes labor and equipment costs for residue disposal, RDF transfer, and haul of unprocessable wastes to landfill.

the cheapest available disposal alternative in order to be implemented. Madison's long previous experience with shredding led them to RDF as a resource recovery option. This fact coupled with the market's need for a fuel compatible with coal and the public's resistance to landfilling contributed to making the system a reality.

Madison also has plans for expansion in the near future. The system has been participating in EPA sponsored RDF test burns at the nearby Oscar Mayer meat processing plant. These tests are now being evaluated, and preliminary results are promising.

MADISON REFERENCES

Boley, G.L. Madison's reliable resource recovery facility. Waste Age, December 1980, pages 71-75.

Boley G.L., K.M. Barlow, and M.L. Smith. Design, Evaluation and Operating Experience of the City of Madison - Madison Gas & Electric Company Energy Recovery Project. In: Proceedings of the National Waste Processing Conference, Washington, D.C., May 11-14, 1980.

Eastbrook, G. Shredding plant gets recycled into a recycler. Waste Age, September 1979, pages 18-25.

NCRR Bulletin. Resource Recovery in Madison. December 1980.

Veller, Robert, Energy Recovery Program; Annual Report. Department of Public Works, City of Madison, January 19, 1981.